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TEXAS AGRICULTURAL EXPERIMENT STATION

BULLETIN NO. 232 AUGUST, 1918

DIVISION OF CHEMISTRY

MINERAL REQUIREMENTS OF SHEEP

B. YOUNGBLOOD, DIRECTOR
COLLEGE STATION, BRAZOS COUNTY, TEXAS.

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BULLETIN NO. 232 AUGUST, 1918

MINERAL REQUIREMENTS OF SHEEP

G. S. FRAPS, Ph. D., CHEMIST IN CHARGE; STATE CHEMIST

The ash constituents of feeds are important to animal nutrition, in that they supply substances needed for the building or upkeep of the animal body. In connection with digestion experiments partly published, certain ash constituents in feed, residues, and excrements were estimated. In connection with other digestion experiments, estimates were made of certain ash constituents in feeds, excrements and urine. The results of this work throw light upon the mineral requirements of sheep, and will be discussed in the following pages.

ABSORPTION OF ASH CONSTITUENTS FROM FEEDS

According to Armsby (Nutrition of Farm Animals, p. 142) the intestines are the usual path for the excretion of calcium, and to some extent magnesium. Phosphoric acid under ordinary conditions is excreted in the faeces of herbivora. The difference between the ash ingredients in the feed and in the solid excrement does not, therefore, represent the amount taken from the food, but is less than the quantity taken. A portion of the lime, magnesia and phosphoric acid has probably been absorbed in the upper portion of the digestive organs, while other quantities have been excreted into the lower portions of the digestive organs.

It is not, therefore, correct to speak of the digestibility of the ash ingredients of feed. The term is a convenient one, however, though in this particular case it means the ash ingredients retained from the food, either more permanently or subsequently eliminated in the urine.

USES OF ASH INGREDIENTS OF FEEDS

It is a well established fact that an animal will die more quickly if fed upon food free from ash than if fed no food at all. The ash ingredients are, therefore, important to the animal. Some of the functions of the ash in the animal body are as follows:

(1) They build up the body skeleton. The bones are composed chiefly of phosphate of lime, but they contain magnesium, fluorine and other elements.

(2) They are constituents of soft parts of the body, where they perform important functions.

(3) Phosphorus and sulphur are essential constituents of certain proteids.

(4) They are necessary constituents of the blood and assist in maintaining a proper concentration and a proper neutrality, and in eliminating an excess of acid.

It is believed that the ash constituents of a feed should not be considered singly, but as a whole. An excess of one ash constituent may affect other constituents. (See Armsby's Nutrition of Farm Animals, p. 399.)

Thus an excess of potash in certain feeds has been thought to cause harmful results, for the reason that in eliminating the potash, the animal also eliminates soda. This deficiency could be counteracted by feeding ordinary salt. Excessive acidity of the ration may cause a loss of lime and other bases, and, incidentally, a loss of phosphoric acid. A deficiency of bases in the feed could be obviated not by using calcium phosphate, which is not basic, but calcium carbonate.

This matter is discussed here on account of its bearing upon the experimental results presented.

DETAILS OF THE EXPERIMENTS

Details of digestion experiments 1 to 18 are given in Texas Bulletin 147; 19 to 37 in Bulletin 166; 76 to 82 in Bulletin 203. The remainder will be published in bulletins to follow.

COMPOSITION OF THE FEEDS

The composition of the feeds is given in table 1. The ash ingredients are important also to show the draft of the plant on the soil, the possible needs of the plant, and the possible fertilizer value of the feed.

Table 1.—Composition of feeds, per cent.

Lab. No.		Silica.	Lime.	Magnesia.	Phosphoric acid.	Potash.
11438–9	Accuff sorgo forage—Exp. 81	.85	.84	.31	.20	2.85
3277–8	Alfalfa hay—Exp. 3	.63	1.52	.40	.48	3.45
6724–5	Alfalfa hay—Exp 24a-29	.48	2.36	.41	.30	2.87
7005–6	Alfalfa hay—Exp. 37–31	1.85	1.38	.52	.58	2.05
12952–3	Alfalfa hay—Exp. 88–92	1.14	1.36	.33	.70	2.05
4252–3	Bermuda hay—Exp. 12	4.01	.63	.27	.56	1.68
6027–8	Bermuda hay—Exp. 20	4.40	.72	.21	.36	1.71
3609–10	Bur clover—Exp. 6	2.40	1.81	.53	1.01	3.50
3883–4	Buffalo grass—Exp. 9	7.05	1.02	.44	.30	1.71
6907–8	Corn bran—Exp. 28	.17	.03	.30	.93	.71
4557–8	Corn shucks—Exp. 17	1.49	.23	.22	.29	.72
12965–6	Cold pressed cotton seed heated—Exp. 89	.24	.26	.74	1.79	1.54
6748–9	Cold pressed cotton seed—Exp. 25	.18	.21	.48	1.50	1.60
7034–5	Cold pressed cotton seed—Exp. 34	.17	.23	.58	1.09	1.35
7048–9	Cottonseed hulls—Exp. 35	.12	.19	.22	.12	1.06
7050–1	Cottonseed meal—Exp. 36	.42	.34	.88	2.22	1.64
3220–1	Cowpea hay—Exp. 1	5.89	3.18	1.70	.36	1.24
3587–8	Johnson grass hay—Exp. 4	12.31	2.00	.62	.53	1.09
4238–9	Johnson grass hay—Exp. 10	3.80	1.02	.31	.51	1.82
4546–7	Kafir fodder—Exp. 15	6.35	.43	.49	.57	3.76
11299-300	Kafir forage—Exp. 79	5.18	.87	.33	.17	2.65
7009–10	Kafir chops—Exp. 32	.42	.08	.30	.80	.52

Table 1.—Composition of feeds, per cent.—Continued.

Lab No.		Silica.	Lime.	Magnesia.	Phosphoric acid.	Potash.
7031–2	Kafir head chops—Exp. 33	1.28	.12	.42	.62	.05
4247–8	Millet—Exp. 11	6.58	.42	.28	.41	1.60
3595–6	Oat hay—Exp. 5	6.68	.36	.25	.54	1.33
11212–3	Peanut hay—Exp. 76	1.72	1.58	.95	.29	1.52
4259–60	Peanut hay—Exp. 13	1.94	1.57	1.30	.33	1.02
2976–7	Peanut hulls—Exp. 90	.37	.43	.29	.16	1.00
4277–8	Para grass hay—Exp. 14	4.34	.60	.32	.38	.78
6064–5	Prairie hay—Exp. 22	4.94	.60	.30	.14	.70
6143–4	Prairie hay—Exp. 23	6.83	.89	.30	.08	.47
11504–5	Rhodes grass hay—Exp. 82	6.65	.51	.09	.65	1.48
6770–1	Rice bran—Exp. 26	4.18	.18	.98	1.89	1.30
11259–60	Rice hay—Exp. 78	12.80	.33	.29	.31	.89
13192–3	Rice hulls—Exp. 91	18.62	.11	.11	.18	.38
6879–80	Rice polish—Exp. 27	1.26	.07	1.07	1.63	1.48
3625–6	Rice straw, Japan—Exp. 7	13.76	.35	.15	.16	1.66
4663–4	Rice straw, Honduras—Exp. 18	14.00	.18	.26	.17	1.29
6998–9	Silage, sorghum and cowpea—Exp. 30	.85	.19	.15	.09	.35
3224–5	Sorghum hay—Exp. 2	4.35	.81	.54	.38	1.71
6033–4	Sorghum hay—Exp. 21	2.85	.57	.50	.28	1.45
5912–3	Tabosa grass hay—Exp. 19	8.65	3.99	.17	.25	.55
6288–9	Tabosa grass hay—Exp. 24	9.40	.36	.12	.97	.57
3649–50	Vetch hay—Exp. 8	7.91	1.38	.42	.82	3.28

DIGESTIBILITY OF THE ASH CONSTITUENTS

The term digestibility is here used to denote the difference between the ingredients in the feed consumed and those excreted in the solid excrement. As already pointed out, and as will appear later on, some of the ash may have been excreted with the solid excrement. It is believed, however, that it is worth while to calculate the factors in the usual way and this has been done in table 2. The feeds are arranged in alphabetical order.

Table 2.—Coefficients of digestibility.

Laboratory number.		Silica.	Lime.	Magnesia.	Phosphoric acid.	Potash.	Sulphur trioxide.	Protein.
11438–9	Accuff sorgo forage—Exp. 81	0	0	1.1	0	87.2	.....	.....
3277–8	Alfalfa hay—Exp. 3	9.2	14.8	25.9	16.1	93.1	64.0	73.8
6724–5	Alfalfa hay—Exp. 24a-29	24.1	10.0	42.5	27.0	88.9	.....	.....
7005–6	Alfalfa hay—Exp. 37-31	9.2	12.2	43.3	20.4	92.5	.....	.....
12952–3	Alfalfa hay—Exp. 88-92	45.7	6.8	22.6	13.9	79.7	.....	.....
4252–3	Bermuda hay—Exp. 12	.6	2.8	49.1	7.0	89.0	74.7	48.8
6027–8	Bermuda hay—Exp. 20	0	0	24,8	0.6	87.0	.....	24.8
3609–10	Bur clover—Exp. 6	41.1	27.6	40.1	36.5	98.2	74.7	80.7
3883–4	Buffalo grass—Exp. 9	8.5	16.8	31.5	7.0	91.4	57.0	53.2
6907–8	Corn bran—Exp. 28	0	0	27.9	27.2	84.3	.....	.....
4557–8	Corn shucks—Exp. 17	18.1	.5	41.7	13.1	64.4	7.2	12.5
12965–6	Cold pressed cotton seed heated—Exp. 89	40.5	0	21.9	41.6	92.8	.....	.....
6748–9	Cold pressed cotton seed—Exp. 25	83.3	80.2	7.6	33.9	99.1	.....	.....
7034–5	Cold pressed cotton seed—Exp. 34	0	56.1	1.9	37.9	90.9	.....	.....
7048–9	Cottonseed hulls—Exp. 35	0	91.1	65.2	40.3	91.5	.....	.....
7050–1	Cottonseed meal—Exp. 36	0	48.4	7.0	37.9	22.7	.....	.....
3220–1	Cowpea hay—Exp. 1	30.6	34.2	47.3	9.7	91.1	74.1	72.3
3587–8	Johnson grass hay—Exp. 4	34.4	33.9	51.3	21.0	81.3	27.6	41.0
4238–9	Johnson grass hay—Exp. 10	15.0	23.0	52.1	19.1	93.6	42.4	51.8
4546–7	Kafir fodder—Exp. 15	25.7	4.9	37.9	22.4	95.2	46.0	63.0

Table 2.—Coefficients of digestibility—Continued.

Laboratory Number.		Silica.	Lime.	Magnesia.	Phosphoric acid.	Potash.	Sulphur trioxide.	Protein.
11299-300	Kafir forage—Exp. 79	0	0	14.2	0	79.2	.....	.....
7009-10	Kafir chops—Exp. 32	9.2	10.0	5.0	24.0	98.9	.....	.....
7031-2	Kafir head chops—Exp. 33	0	75.5	3.7	0	86.9	.....	.....
4247-8	Millet—Exp. 11	28.0	19.4	40.5	15.6	85.4	50.4	30.3
3595-6	Oat hay—Exp. 5	24.4	19.5	45.8	0	86.0	41.7	58.5
11212-3	Peanut hay—Exp. 76	0	7.0	37.0	9.0	94.5	.....	.....
4259-60	Peanut hay—Exp. 13	0	14.0	51.6	7.1	91.3	61.7	78.6
2976-7	Peanut hulls—Exp. 90	0	0	37.0	0	64.0	.....	.....
4277-8	Para grass hay—Exp. 14	45.9	12.8	39.2	12.8	.....	56.8	9.9
6064-5	Prairie hay—Exp. 22	0	17.3	47.7	0	56.5	.....	.....
6143-4	Prairie hay—Exp. 23	28.0	32.0	60.2	0	59.1	.....	.....
11504-5	Rhodes grass hay—Exp. 82	12.5	0	4.0	5.9	88.8	.....	.....
6770-1	Rice bran—Exp. 26	5.8	39.1	11.9	58.4	99.6	.....	.....
11259-60	Rice hay—Exp. 78	0	0	6.1	0	67.5	.....	.....
13192-3	Rice hulls—Exp. 91	24.7	0	29.9	0	0	.....	.....
6879-80	Rice polish—Exp. 27	21.8	10.0	11.4	40.3	10.0	.....	.....
3625-6	Rice straw, Japan—Exp. 7	.7	0	40.8	0	85.5	2.1	16.8
4663-4	Rice straw, Honduras—Exp. 18	10.8	0	36.4	13.5	91.4	15.9	26.6
6998-9	Silage, Sorghum and Cowfer—Exp. 30	.6	2.1	30.5	0	77.0	.....	.....
3224-5	Sorghum hay—Exp. 2	33.7	25.9	38.7	5.3	92.5	43.0	31.6
6033-4	Sorghum hay—Exp. 21	0	.3	31.0	15.0	87.8	.....	.....
5912-3	Tabosa grass hay—Exp. 19	3.8	89.9	39.7	0	36.6	.....	.....
6288-9	Tabosa grass hay—Exp. 24	21.1	11.6	72.9	74.0	61.1	.....	.....
3649-50	Vetch hay—Exp. 8	17.3	39.5	38.1	25.9	94.5	74.5	74.2

Potash. Potash is highly digested. The average digestibility is 83.2. In no case is the digestibility negative.

Phosphoric acid. The average digestibility of phosphoric acid is 22.5. In some of the tests the digestibility is negative. The cause of this will be discussed later.

Lime. The average digestibility of lime is 32.3 and, like phosphoric acid, in a number of tests the digestibility is negative.

Magnesia. Magnesia has a digestibility of 32.3, practically the same as lime, but with no negative tests. In this respect, magnesia is more closely related to potash than to lime.

Sulphur trioxide. The sulphur is probably for the most part in protein compounds. The digestibility of protein is placed in the table for comparison. While there are individual variations, the average digestibility of the sulphur trioxide is nearly the same as for protein, being 47.9 for sulphur trioxide and 48.4 for protein.

Silica. Silica is really the *insoluble ash* and the matter is complicated by the sand and dirt found on the feed. The average digestibility is 22.2 and there are a number of negative tests.

Table 3.—Grams eaten and digested per day.

	Silica.	Lime.	Magnesia.	Phosphoric acid.	Potash.	Sulphur Trioxide.
Accuff sorgo forage, D. E. 81—Eaten	28.99	3.55	1.31	.85	12.06	.....
Digested	—5.14	—.30	.09	—.13	10.47	.....
Accuff sorgo forage, D. E. 81—Eaten	30.92	3.79	1.40	.90	12.86	.....
Digested	—3.81	—.07	.30	—.77	11.27	.....
Alfalfa hay, Exp. 3—Eaten	3.46	8.36	2.20	2.64	19.01	3.62
Digested	0.96	1.15	0.63	0.05	17.05	2.27
Alfalfa hay, Exp. 3—Eaten	3.46	8.36	2.20	2.64	19.00	3.62
Digested	—0.56	1.60	0.78	1.27	17.57	2.32
Alfalfa hay, Exp. 3—Eaten	3.40	8.20	2.16	2.60	18.64	3.55
Digested	—0.62	0.95	0.47	0.08	18.10	2.36
Alfalfa hay, Exp. 24a—Eaten	2.40	11.80	2.05	1.50	14.35	.....
Digested	.80	1.62	1.30	0.68	13.38	.....
Alfalfa hay, Exp. 24a—Eaten	2.40	11.80	2.05	1.50	14.35	.....
Digested	.93	1.53	1.20	.42	12.28	.....
Alfalfa hay, Exp. 29—Eaten	2.40	11.80	2.05	1.50	14.35	.....
Digested	.20	.47	.58	.15	13.55	.....
Alfalfa hay, Exp. 29—Eaten	2.40	11.80	2.05	1.50	14.35	.....
Digested	.38	1.13	.72	.38	13.02	.....
Alfalfa hay, Exp. 37—Eaten	9.23	6.88	2.60	2.90	10.23	.....
Digested	.03	.73	.93	.62	9.65	.....
Alfalfa hay, Exp. 37—Eaten	9.23	6.88	2.60	2.90	10.23	.....
Digested	1.37	.83	1.07	1.03	9.18	.....
Alfalfa hay, Exp. 31—Eaten	9.25	6.90	2.60	2.90	10.25	.....
Digested	1.18	1.02	1.18	.58	9.80	.....
Alfalfa hay, Exp. 31—Eaten	9.25	6.90	2.60	2.90	10.25	.....
Digested	.78	.78	1.25	.13	9.30	.....
Alfalfa hay, Exp. 88—Eaten	6.82	8.12	1.96	4.19	12.27	.....
Digested	3.31	.61	.47	.02	7.54	.....
Alfalfa hay, Exp. 88—Eaten	6.84	8.16	1.97	4.20	12.30	.....
Digested	3.49	.76	.33	.87	9.86	.....
Alfalfa hay, Exp. 92—Eaten	6.84	8.16	1.97	4.20	12.30	.....
Digested	2.03	—.60	.50	.63	9.97	.....
Alfalfa hay, Exp. 92—Eaten	6.84	8.16	1.97	4.20	12.30	.....
Digested	3.67	.84	.47	.84	10.81	.....
Bermuda hay, Exp. 12—Eaten	19.99	3.13	1.35	2.80	8.37	3.64
Digested	0.11	0.13	0.6	0.56	7.32	2.58
Bermuda hay, Exp. 12—Eaten	19.99	3.13	1.35	2.80	8.37	3.64
Digested	0.17	0.13	0.47	0.58	7.52	2.82
Bermuda hay, Exp. 12—Eaten	19.95	3.13	1.35	2.80	8.36	3.64
Digested	0.07	0.20	0.91	—0.18	7.50	2.73
Bermuda hay, Exp. 20—Eaten	24.36	4.07	1.20	2.09	10.62	.....
Digested	—3.76	—.09	.14	—1.18	8.34	.....
Bermuda hay, Exp. 20—Eaten	26.38	4.33	1.26	2.12	10.12	.....
Digested	—.31	—.22	.31	.01	8.81	.....
Bermuda hay, Exp. 20—Eaten	26.26	4.31	1.25	2.12	10.25	.....
Digested	—.44	.79	.28	—.61	8.24	.....
Bur clover, Exp. 6—Eaten	11.99	9.04	2.65	5.04	17.47	4.99
Digested	4.75	2.95	1.03	1.2	17.16	3.85
Bur clover, Exp. 6—Eaten	11.99	9.04	2.65	5.02	17.44	4.99
Digested	5.10	2.05	1.08	2.47	17.11	3.60
Buffalo grass, Exp. 9—Eaten	35.25	5.10	2.20	1.50	8.55	2.40
Digested	3.03	1.18	0.8	0.37	7.72	1.37
Buffalo grass, Exp. 9—Eaten	35.20	5.09	2.20	1.50	8.54	2.40
Digested	—0.23	1.02	0.55	0.27	7.78	1.35
Buffalo grass, Exp. 9—Eaten	34.96	5.06	2.19	1.49	8.49	2.38
Digested	5.92	0.35	0.72	—0.05	7.85	1.36
Corn bran and alfalfa, Exp. 28—Eaten	1.95	7.14	1.93	3.78	10.75	.....
Digested	.60	.08	.73	.70	10.32	.....
Corn bran and alfalfa, Exp. 28—Eaten	1.95	7.14	1.93	3.78	10.75	.....
Digested	.28	.02	.68	1.28	9.80	.....
Corn shucks, Exp. 17—Eaten	6.05	.94	.89	1.18	2.91	.74
Digested	—1.03	—0.12	0.45	0.46	2.06	0.03
Corn shucks, Exp. 17—Eaten	5.99	.93	.87	1.16	2.89	.73
Digested	0.32	0.01	0.37	—0.25	1.71	0.03
Corn shucks, Exp. 17—Eaten	5.98	.93	.87	1.16	2.87	.73
Digested	—0.40	—0.57	0.29	—0.56	1.81	0.12
Cold pressed cottonseed and alfalfa, D. E. 25—Eaten	4.97	7.72	2.67	5.40	13.62	.....
Digested	3.50	1.18	.43	2.03	12.63	.....
Cold pressed cottonseed and alfalfa, D. E. 25—Eaten	4.97	7.72	2.67	5.40	13.62	.....
Digested	3.33	1.27	.73	1.48	12.73	.....

Table 3.—Grams eaten and digested per day—Continued.

	Silica.	Lime.	Magnesia.	Phosphoric acid.	Pot ash.	Sulphur Trioxide.
Cold pressed cottonseed and alfalfa, D. E. 34—Eaten	6.07	4.62	2.37	4.35	10.20	.....
Digested	.60	1.15	.22	1.50	9.63	.....
Cold pressed cottonseed and alfalfa, Exp. 34—Eaten	6.07	4.62	2.37	4.35	10.20	.....
Digested	4.28	.62	.33	1.08	9.10	.....
Cold pressed cottonseed (burnt) and alfalfa, D. E. 89—Eaten	4.14	4.86	3.21	7.47	10.77	.....
Digested	2.14	—.13	1.20	4.17	9.34	.....
Cold pressed cottonseed (burnt) and alfalfa, D. E. 89—Eaten	4.14	4.86	3.21	7.47	10.77	.....
Digested	—3.33	—2.49	.07	.87	9.04	.....
Cottonseed hulls and meal and alfalfa, D. E. 35—Eaten	6.47	4.99	3.46	6.05	10.42	.....
Digested	—5.30	1.20	1.52	1.92	9.23	.....
Cottonseed hulls and meal and alfalfa, Exp. 35—Eaten	6.47	4.99	3.46	6.05	10.42	.....
Digested	—4.43	.87	1.22	1.77	9.69	.....
Cottonseed meal and alfalfa, Exp. 36—Eaten	6.83	5.15	3.27	7.75	11.07	.....
Digested	—.52	1.28	—.30	3.40	5.92	.....
Cottonseed meal and alfalfa, Exp. 36—Eaten	6.82	5.15	3.27	7.75	11.07	.....
Digested	.02	.70	.30	2.08	10.12	.....
Cowpea hay, Exp. 1—Eaten	29.45	15.92	8.50	1.80	6.20	5.80
Digested	9.26	5.16	4.02	0.01	5.60	4.31
Cowpea hay, Exp. 1—Eaten	29.45	15.92	8.50	1.80	6.20	5.80
Digested	8.73	5.68	4.09	0.01	5.70	4.28
Guam grass, Exp. 16—Eaten	17.35	2.15	1.40	2.75	8.55	1.85
Digested	0.5	0.37	0.68	0.56	6.77	0.58
Guam grass, Exp. 16—Eaten	17.35	2.15	1.40	2.75	8.55	1.85
Digested	1.42	0.28	0.57	1.63	7.62	0.68
Guam grass, Exp. 16—Eaten	17.35	2.15	1.40	2.75	8.55	1.85
Digested	0.92	—0.41	0.21	0.00	6.33	0.63
Johnson grass hay, Exp. 4—Eaten	53.71	8.73	2.70	2.32	4.77	1.57
Digested	25.32	3.09	1.38	—0.15	3.22	0.2
Johnson grass hay, Exp. 4—Eaten	48.15	7.83	2.43	2.10	4.37	1.41
Digested	19.7	2.47	1.22	1.15	3.78	0.51
Johnson grass hay, Exp. 4—Eaten	52.97	8.60	2.66	2.29	4.74	1.55
Digested	25.22	2.97	1.38	0.16	4.25	0.52
Johnson grass hay, Exp. 10—Eaten	18.95	5.09	1.55	2.54	9.07	1.65
Digested	2.75	1.35	0.73	0.35	8.45	0.73
Johnson grass hay, Exp. 10—Eaten	18.97	5.10	1.55	2.55	9.09	1.65
Digested	0.45	1.0	0.62	0.76	8.50	0.65
Johnson grass hay, Exp. 10—Eaten	18.97	5.10	1.55	2.55	9.09	1.65
Digested	1.31	1.16	1.06	0.35	8.56	0.71
Kafir fodder, Exp. 15—Eaten	31.75	2.15	2.45	2.85	18.80	1.65
Digested	9.02	0.21	0.98	1.01	18.27	0.88
Kafir fodder, Exp. 15—Eaten	31.75	2.15	2.45	2.85	18.80	1.65
Digested	6.81	0.26	0.92	0.32	18.15	0.77
Kafir fodder, Exp. 15—Eaten	34.21	2.31	2.64	3.07	20.25	1.77
Digested	9.27	0.11	0.93	0.62	18.6	0.66
Kafir forage, Exp. 79—Eaten	24.98	4.19	1.59	.82	12.78	.....
Digested	—12.80	—.11	.36	—.23	10.77	.....
Kafir forage, Exp. 79—Eaten	25.09	4.21	1.46	.82	12.81	.....
Digested	—9.60	—.17	.09	—1.13	9.51	.....
Kafir chops and alfalfa, Exp. 32—Eaten	—6.82	4.37	1.53	3.48	7.72	.....
Digested	—.02	.82	.30	.90	7.28	.....
Kafir chops and alfalfa, Exp. 32—Eaten	6.82	4.37	1.53	3.48	7.72	.....
Digested	.75	.75	.33	1.02	7.18	.....
Kafir head chops and alfalfa, Exp. 33—Eaten	9.37	5.93	1.53	1.50	8.15	.....
Digested	.12	2.38	.33	—1.08	7.60	.....
Kafir head chops and alfalfa, Exp. 33—Eaten	9.38	5.93	1.53	1.50	8.15	.....
Digested	—3.08	2.33	.17	—1.25	7.42	.....
Millet, Exp. 11—Eaten	32.62	2.09	1.38	2.09	7.32	1.59
Digested	11.18	0.17	0.62	0.46	6.43	0.81
Millet, Exp. 11—Eaten	32.74	2.09	1.39	2.09	7.96	1.59
Digested	7.65	0.50	0.55	0.72	2.59	0.75
Millet, Exp. 11—Eaten	32.65	2.09	1.39	2.09	7.94	1.59
Digested	8.6	0.53	0.51	1.08	5.82	0.83
Oat hay, Exp. 5—Eaten	31.95	1.72	1.20	1.60	6.40	2.59
Digested	8.01	0.03	0.58	—0.63	5.7	1.71
Oat hay, Exp. 5—Eaten	31.37	1.69	1.18	2.55	6.30	2.52
Digested	1.06	0.41	0.5	—0.18	5.27	1.48

Table 3.—Grams eaten and digested per day.—Continued.

	Silica.	Lime.	Magnesia.	Phosphoric acid.	Potash.	Sulphur Trioxide.
Peanut hay, Exp. 13—Eaten	9.70	7.85	6.50	1.65	5.10	2.35
Digested	—2.76	1.37	2.46	—0.35	4.46	1.48
Peanut hay, Exp. 13—Eaten	9.70	7.85	6.50	1.65	5.10	2.35
Digested	—5.68	0.58	3.33	—0.33	4.77	1.35
Peanut hay, Exp. 13—Eaten	9.70	7.85	6.50	1.65	5.10	2.35
Digested	—6.8	1.32	4.26	—0.11	4.73	1.51
Peanut hay, D. E. 76—Eaten	10.32	9.48	5.70	1.74	9.12	.....
Digested	—1.69	.76	1.90	.31	8.61	.....
Peanut hay, D. E. 76—Eaten	10.29	9.45	5.68	1.73	9.10	.....
Digested	—1.66	.57	2.31	.09	8.57	.....
Peanut hay and alfalfa, D. E. 90—Eaten	4.47	5.32	1.82	2.57	9.01	.....
Digested	1.44	—0.4	.70	—.22	6.90	.....
Peanut hulls and alfalfa, D. E. 90—Eaten	4.53	5.37	1.86	2.58	9.15	.....
Digested	1.09	—.54	.36	—.71	—6.64	.....
Para grass hay, Exp. 14—Eaten	20.55	2.85	1.51	1.79	.....	3.84
Digested	1.6	0.37	0.58	0.1	.....	2.12
Para grass hay, Exp. 14—Eaten	21.49	2.98	1.59	1.86	.....	4.01
Digested	5.17	0.10	0.52	0.61	.....	2.25
Para grass hay, Exp. 14—Eaten	18.19	2.51	1.34	1.59	.....	3.40
Digested	6.5	0.55	0.61	—0.77	.....	2.00
Prairie hay, Exp. 22—Eaten	19.79	2.51	1.14	.50	2.54	.....
Digested	—1.06	.90	.46	—.72	.77	.....
Prairie hay, Exp. 22—Eaten	23.47	2.82	1.46	.66	3.26	.....
Digested	—1.60	.42	.64	—.49	2.39	.....
Prairie hay, Exp. 22—Eaten	24.44	3.00	1.49	.70	3.49	.....
Digested	1.32	.36	.88	—.20	2.34	.....
Prairie hay, Exp. 23—Eaten	18.81	2.32	1.40	.16	1.24	.....
Digested	8.38	.11	.11	—.26	1.00	.....
Prairie hay, Exp. 23—Eaten	33.47	4.24	1.44	.39	2.52	.....
Digested	8.87	.79	.76	—.74	1.25	.....
Prairie hay, Exp. 23—Eaten	33.87	4.37	1.45	.39	2.56	.....
Digested	6.42	1.33	.70	—.60	.96	.....
Rhodes grass hay, D. E. 82—Eaten	28.21	2.16	.38	2.76	6.28	.....
Digested	3.29	—.16	—.03	.33	5.50	.....
Rhodes grass hay, D. E. 82—Eaten	40.04	3.07	.54	3.91	8.91	.....
Digested	5.31	—.49	.43	—.03	7.03	.....
Rice bran and alfalfa, Exp. 26—Eaten	13.97	7.62	4.17	6.57	10.73	.....
Digested	1.73	1.13	.88	3.82	11.28	.....
Rice bran and alfalfa, Exp. 26—Eaten	13.97	7.62	4.17	6.57	10.73	.....
Digested	.42	.63	.85	3.27	11.70	.....
Rice hay, D. E. 78—Eaten	41.17	1.06	.93	1.00	2.86	.....
Digested	—3.79	—1.14	—.23	—.59	1.40	.....
Rice hay, D. E. 78—Eaten	73.14	1.88	1.77	1.77	5.08	.....
Digested	—6.31	—.94	.20	—.09	4.37	.....
Rice hulls and alfalfa, D. E. 91—Eaten	26.31	3.84	.97	2.23	6.39	.....
Digested	12.98	—.19	.31	.54	5.67	.....
Rice hulls and alfalfa, D. E. 91—Eaten	58.05	4.39	1.31	2.63	7.26	.....
Digested	.62	—.84	.41	—.94	4.59	.....
Rice polish and alfalfa, Exp. 27—Eaten	5.22	9.03	4.45	5.78	13.05	.....
Digested	.87	2.95	1.05	2.12	11.92	.....
Rice polish and alfalfa, Exp. 27—Eaten	5.22	9.03	4.45	5.78	13.05	.....
Digested	.....	.....	.....	2.12	12.33	.....
Rice straw, Japan, Exp. 7—Eaten	61.26	1.55	.66	.71	7.37	.97
Digested	1.27	—0.25	0.23	—0.96	5.96	0.06
Rice straw, Japan, Exp. 7—Eaten	56.68	1.44	.61	.69	6.79	.89
Digested	—0.4	—0.08	0.35	0.01	6.01	0.05
Rice straw, Japan, Exp. 7—Eaten	59.00	1.50	.64	.70	7.07	.90
Digested	—0.07	—0.05	0.18	—0.27	6.16	0.01
Rice straw, Honduras, Exp. 18—Eaten	55.95	.73	.10	.67	5.16	.87
Digested	6.48	—0.52	0.46	—0.12	4.63	0.16
Rice straw, Honduras, Exp. 18—Eaten	56.77	.74	1.05	.69	5.24	.89
Digested	10.25	—0.25	0.21	—0.58	4.81	0.22
Rice straw, Honduras, Exp. 18—Eaten	42.40	.55	.79	.51	3.91	.66
Digested	1.15	—0.97	0.35	—0.54	3.62	0.02

Table 3.—Grams eated and digested per day—Continued.

	Silica.	Lime.	Magnesia.	Phosphoric acid.	Potash.	Sulphur Trioxide.
Silage, sorghum and cowpea, Exp. 30 —Eaten	12.75	2.85	2.25	1.35	5.25	.....
Digested	.15	.12	1.15	—1.02	4.25	.....
Silage, sorghum and cowpea, Exp. 30 —Eaten	12.71	2.83	2.25	1.35	5.23	.....
Digested	—1.82	—.03	.23	—.93	3.82	.....
Sorghum hay, Exp. 2—Eaten	26.10	4.86	3.24	2.27	10.26	1.97
Digested	8.31	1.03	1.15	—0.02	9.02	0.81
Sorghum hay, Exp. 2—Eaten	21.77	4.05	2.70	1.90	8.55	1.65
Digested	7.4	0.87	1.06	—0.06	7.98	0.71
Sorghum hay, Exp. 2—Eaten	21.73	4.05	2.70	1.90	8.54	1.65
Digested	7.68	1.42	1.11	0.03	8.21	0.73
Sorghum hay, Exp. 21—Eaten	15.39	3.08	2.74	1.52	8.16	.....
Digested	—.92	—.10	.96	—.69	6.76	.....
Sorghum hay, Exp. 21—Eaten	16.99	3.40	2.92	1.66	8.74	.....
Digested	—2.21	—.31	.98	—.64	7.96	.....
Sorghum hay, Exp. 21—Eaten	14.94	3.00	2.57	1.55	7.54	.....
Digested	—2.85	.02	.62	—.18	6.75	.....
Tobosa grass hay, Exp. 19— —Eaten	27.24	15.54	.51	.83	1.70	.....
Digested	5.10	14.29	.21	—.30	.74	.....
Tobosa grass hay, Exp. 19 —Eaten	34.55	15.93	.67	1.00	2.20	.....
Digested	1.80	13.98	.25	—.39	.66	.....
Tobosa grass hay, Exp. 24 —Eaten	46.76	1.79	.60	4.80	2.84	.....
Digested	9.88	.40	.38	4.00	1.56	.....
Tobosa grass hay, Exp. 24 —Eaten	47.00	1.80	.60	4.85	2.85	.....
Digested	9.86	.05	.50	3.64	1.91	.....
Vetch hay, Exp. 8—Eaten	39.55	6.90	.21	4.1	16.40	4.5
Digested	6.83	2.72	0.8	1.06	15.48	3.35

RELATION BETWEEN QUANTITY EATEN AND QUANTITY DIGESTED

The results secured were studied in order to see if any relation could be traced between the quantity of the ingredients in the food eaten and the quantity digested. For this purpose, the tests were divided into groups according to the quantity of the ingredients eaten. Some striking results were secured, which will be discussed in detail below. Table 3 shows the grams eaten and digested, arranged according to the kind of feed.

Table 4.—Average lime eaten and digested.

Grams eaten (Group)	0-2	2-4	4-6	6-8	8-12	12+
Average grams eaten	1.25	2.73	4.78	7.38	9.32	15.83
Number of tests	15	29	32	15	19	4
Number of losses	5	9	9	0	1	0
Number of gains	10	20	23	15	18	4
Average digested, grams	—.27	+.13	.59	1.08	1.67	9.78
Increase fed over preceding group	.....	1.48	2.05	2.60	1.94	6.51
Increase digested over preceding group	.....	.40	.46	.49	.59	8.11
Digestibility of increase	.....	26	23	18	30	100

Lime. The average results for lime are presented in table 4. The number of losses is somewhat irregular in the various groups. There is, on an average, a relation between the quantity of lime eaten and the quantity fed. The quantity of lime digested in the first group of

tests is negative, and after this, there is a regular increase in the quantity of lime digested, as the quantity of lime fed increases. These facts could only be brought out by using a large number of tests, as here given. If the increase in the quantity of lime fed in each group over the preceding group is considered in connection with the increased quantity of lime digested, the digestibility of the additional lime is found to be 18 to 30 per cent. The digestibility of the lime may be taken to average 25 per cent.

These figures point to a fairly constant digestibility of lime by the animal, and a fairly constant excretion of lime in the solid excrement. In the first group, the quantity excreted is greater than the quantity digested, and so there is an apparent loss. The amount of the excretion may be estimated from the data. In the first group, if a digestibility of 25 per cent. of the 1.25 grams lime fed is assumed, the amount digested would be .31 gram, and this, added to the .27 gram lost, would give .58 gram excreted in the solid excrement. In group 2, a digestibility of 25 per cent. would yield .68 gram digested, and, if the .13 gram retained is subtracted, it would give .55 gram excreted in the solid excrement. In group 3, 25 per cent. of 4.78 is 1.19, and subtracting .59 there is shown to be .60 gram excreted in the solid excrement.

Hence one is justified in assuming a digestibility of 25 per cent. for lime and a daily excretion of .60 gram in the solid excrement.

Table 5.—Average phosphoric acid eaten and digested.

Grams Eaten (Group).	0-1	1-2	2-3	3-5	5+
Average grams eated	0.64	1.56	2.54	4.05	6.29
Number of tests	17	34	33	15	14
Number of losses	17	16	8	1	0
Number of gains	0	18	25	14	14
Average digested, grams	—.46	+.004	+.34	1.21	2.34
Increase fed over the preceding group	.....	0.92	.98	1.51	2.24
Increase digested over preceding group	.....	.46	.34	.87	1.13
Digestibility of increase	.....	50	34	58	50

Phosphoric acid. The results of the phosphoric acid tests are given in table 5. The number of losses in the tests decreases regularly as the quantity of phosphoric acid fed increases. There are no gains in the first group and no losses in the last one.

There is a loss of phosphoric acid in the first group, and after this there is a gain in the quantity absorbed, increasing as the quantity fed increases. If the preceding group be subtracted from the next group, there is found to be a digestibility of 34 to 58 per cent. for the additional phosphoric acid fed. These figures point to a fairly constant digestibility of phosphoric acid by the animal, and a fairly constant excretion of phosphoric acid in the excrement. The digestibility of the phosphoric acid may be taken to be 50 per cent. In the first group, 50 per cent. of the .64 gram fed would be .32 gram, and this, added to .46 gram lost, would be .78 gram excreted in the solid excrement. In the

second group there is practically no phosphoric acid digested. A digestibility of 50 per cent. would give .78 gram phosphoric acid lost in the solid excrement. In group 3, 1.27 grams phosphoric acid would be digested. This, less .34 gram, would give .93 gram in the solid excrement.

One is justified in assuming a digestibility of 50 per cent. for the phosphoric acid, and a loss of .8 gram per day of phosphoric acid in the solid excrement.

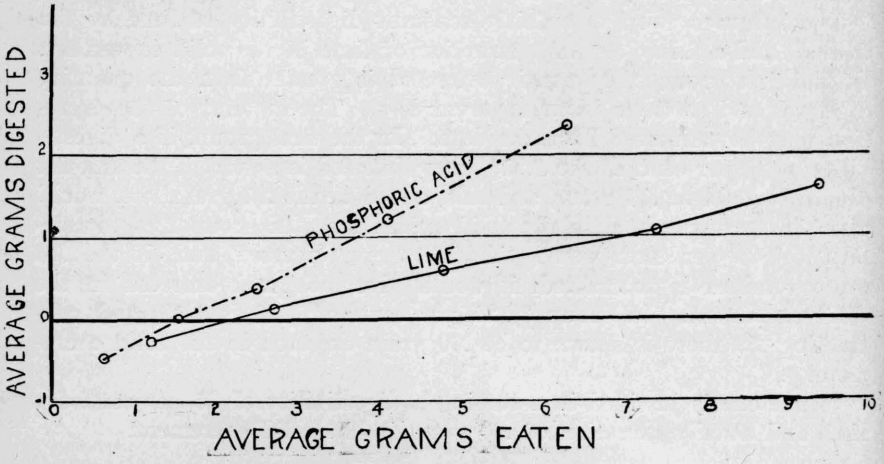

Chart showing relation of lime and phosphoric acid digested by sheep to the amount eaten.

Relation of lime to phosphoric acid. In group 2 of the phosphoric acid tests, where one to two grams are fed, there are 16 losses of phosphoric acid and 18 gains. These tests were tabulated with respect to the lime digested as shown in table 6. In test 19, an excessive quantity of lime was eaten and it is excluded from the discussion.

Table 6.—Relation of lime to phosphoric acid lost or gained in group 2.

	Loss.	Gain.	Diff.
Phosphoric acid digested, grams	—.43	+.39	.82
Number of tests	16	18	.....
Lime eaten, grams	4.38	7.69	3.31
Lime digested, grams	1.18	1.44	.26
Lime eaten, exclusive of No. 19	3.39	.....	4.30
Lime digested, exclusive of No. 19	.31	.....	1.11

The lime eaten when there were losses of phosphoric acid average 3.39 grams, and when there were gains, 7.69 grams. Thus, a higher consumption of lime was accompanied by a better retention of phosphoric acid. An increased consumption of 4.30 grams lime and an increased digestion of 1.11 grams lime, was accompanied by an increased retention of .82 gram phosphoric acid. An increased digestion of 1 gram lime was thus accompanied by an increased retention of .74

grams phosphoric acid. The ratio of lime to phosphoric acid in tricalcium phosphate is 1:0.80.

Table 7.—Average magnesia eaten and digested.

Grams Eaten (Group)	0-1	1-2	2-3	3+
Average grams eaten	.66	1.47	2.23	4.92
Number of tests	16	35	44	17
Number of losses	2	0	0	0
Number of gain	14	35	44	17
Average digested, grams	.28	.49	.77	1.81
Increase fed over preceding group	.....	.81	.76	2.69
Increase digested over preceding group	.....	.21	.28	1.04
Digestibility of increase	(42)	26	36	39

Magnesia. The quantity of magnesia digested increases with the quantity fed (table 7). There is no evidence of any excretion of magnesia in the solid excrement. Only two losses of magnesia occurred.

Potash. The quantity of potash digested increases with the quantity of potash fed. There is no evidence of excretion of potash into the solid excrement.

Table 8.—Average potash eaten and digested.

Grams Eaten (Group)	0-5	5-10	10-15	15-20
Average grams eaten	2.97	7.64	13 68	18.42
Number of tests	17	48	36	49
Number of losses	0	0	0	0
Average digested, grams	1.87	6.43	10.26	17.49

Silica. With the exception of the second group, the quantity of silica (insoluble ash) increases as the quantity fed increases. This is evidence that there is actually a digestion of silica by sheep.

Table 9.—Average silica eaten and digested.

Grams Eaten (Group)	0-5	5-10	10-20	20-30	30+
Average grams eaten	3.40	7.22	16.12	25.11	43.27
Number of tests	15	26	23	17	30
Number of losses	3	7	5	6	4
Number of gains	12	19	18	11	26
Average digested, grams	.74	.39	1.79	3.26	6.58
Increase fed over preceding group	.....	3.82	8.90	8.99	15.16
Increase digested over preceding group	.....	0	1.49	1.47	3.32
Digestibility of increase	(22)	0	16	16	22

BALANCE EXPERIMENTS

In twenty tests with ten rations, the urine was analyzed in addition to the feeds and solid excrements, this constituting a balance experiment. (See table 12.) These tests have been divided into groups as given in tables 10 and 11, but the number of tests is not sufficient to make averages that are as significant as those just discussed.

Table 10.—Phosphoric acid gained or lost in balance experiment.

Grams Eaten (Group)	0-1	1-2	2-3	3-5	5+
Average grams eaten	0.84	1.56	2.56	4.14	5.40
Number of tests	4	4	5	5	2
Number of losses	4	3	2	2	0
Average digested, grams	—.56	—.11	+.17	.44	2.52
Average in urine, grams	.03	.02	.11	.05	1.07
Loss or gain, retained grain	—.59	—.13	.06	.39	1.45
Increase fed over preceding group	.....	.72	1.00	1.58	1.26
Increase digested over preceding group	.....	.45	.28	.27	2.25
Digestibility of increase	.....	63	28	17	.....
Increased retention over preceding group	.....	.46	.19	.33	1.06
Percentage retained	.....	64	19	21	83

Phosphoric acid. The quantity of phosphoric acid digested (table 10) increases with the quantity fed. The quantity in the urine is fairly constant. The average quantity retained in the body increases with the quantity fed. The percentage retention is irregular.

Lime. The averages (table 11) are irregular and show the danger of drawing conclusions from a small number of experiments. With the exception of the first group, the quantity of lime in the urine is fairly constant.

Table 11.—Lime gained or lost in balance experiment.

Grams Eaten (Group)	0-2	2-4	4-6	6-8	8-12	+12
Average grams eaten	1.47	3.28	4.69	7.47	8.75	.....
Number of tests	2	5	5	2	6	.....
Number of losses	2	5	5	2	1	.....
Average digested, grams	—1.04	—.24	—.34	—1.31	.48	.....
Average in urin, grams	.21	.09	.07	.07	.08	.....
Loss or gain retained, grams	—1.25	—.33	—.41	—1.38	.40	.....
Increase fed over preceding group	.....	1.81	1.41	0	1.28	.....
Increase digested over preceding group	.....	.80	0	0	1.79	.....
Digestibility of increase	.....	44	0	0	.....	.....
Increased retention over preceding group	.....	.92	0	0	1.78	.....
Percentage retained	.....	49	0	0	.....	.....

Silica, magnesia, potash. In some cases, the balances are negative, in others they are positive. On an average there are gains of 1 gram silica (insoluble ash), .18 gram magnesia and .19 gram potash per head per day. The silica in the urine averages .44 grams.

MINERAL REQUIREMENTS OF SHEEP

The experiments presented throw some light upon the mineral requirements of sheep. The sheep used were one to three years old, weighing about 100 pounds.

Phosphoric acid. With an average of .80 gram in the solid excrement and .05 gram in the urine, the amount digested for a balance should be .85 gram per day. With a digestibility of 50 per cent. the amount required in the feed for a balance would be 1.70 grams per day.

Lime. With an average excretion of .60 grams in the solid excrement and .09 gram in the urine, the amount digested per day should be .69 gram. With a digestibility of 25 per cent., the amount required in the feed for a balance would be 2.8 grams per day. The animal may get along with less than this quantity, but will probably need more.

Potash. Although potash is found in wool fat, and hence is stored by the animal in this form, it is probable that the needs of the animal for potash are small and easily met. A retention of .2 gram per day is indicated by the balance experiment. Sufficient potash is probably furnished sufficient for the needs of the animal by all feeds.

Magnesia. The work throws no light upon the needs of the animal for magnesia. With .32 gram in the urine and an average digestibility of 32 per cent., balance would be maintained with 1 gram per day. The balance experiment showed a retention of 18 grams, which would involve .54 gram additional, probably making the average needs of the animal 1.54 grams per day. The amount of magnesia needed is small and probably supplied in all cases.

Table 12.—Income and outgo of minerals of feeds per day.

	Silica.	Lime.	Magnesia.	Phosphoric acid.	Potash.
Period 76—Peanut hay.					
Sheep 1—Total eaten	10.32	9.48	5.70	1.74	9.12
Digested	—1.67	0.75	1.89	0.31	8.62
In urine	.19	.05	.54	.01	6.42
Loss or gain	—1.86	.70	1.35	.30	2.20
Sheep 2—Eaten	10.30	9.45	5.68	1.73	9.09
Digested	—1.65	.57	2.31	—.08	8.59
In urine	.12	.19	.50	.01	6.94
Loss or gain	—1.77	.38	1.81	—.09	1.65
Period 78—Rice hay.					
Sheep 1—Eaten	+41.17	1.06	.93	1.00	2.86
Digested	—3.79	—1.14	—.23	—.59	1.40
In urine	.10	.15	.24	.03	3.10
Loss or gain	—3.89	—1.29	—.47	—.62	—1.70
Sheep 2—Eaten	+73.13	1.88	1.77	1.77	5.08
Digested	—6.31	—.94	—.20	—.09	4.37
In urine	.08	.27	.45	.03	6.26
Loss or gain	—6.39	—1.21	—.65	—.12	—1.89
Period 79—Black kafir forage.					
Sheep 1—Eaten	24.98	4.19	1.59	.82	12.78
Digested	—12.80	—.11	.36	—.23	10.77
In urine	.12	.09	.28	.02	9.78
Loss or gain	—12.92	—.20	.08	—.25	.99
Sheep 2—Eaten	+25.09	4.21	1.46	.82	12.81
Digested	—9.60	—.17	.09	—1.13	9.51
In urine	.28	.08	.17	.03	10.16
Loss or gain	—9.88	—.25	—.08	—1.16	—.65
Period 81—Acuff sorgo forage.					
Sheep 2—Eaten	28.98	3.55	1.31	.84	12.06
Digested	—5.14	—.30	—.09	—.13	10.47
In urine	.19	.03	.10	.04	8.68
Loss or gain	—5.33	—.33	—.19	—.17	1.78
Sheep 3—Eaten	30.92	3.79	1.40	.90	12.86
Digested	—3.81	—.07	.30	—.77	11.27
In urine	.26	.08	.76	.03	10.24
Loss or gain	—4.07	—.15	—.46	—.80	1.03

Table 12.—Income and outgo of minerals of feeds per day—Continued.

	Silica.	Lime.	Magnesia.	Phosphoric acid.	Potash.
Period 82—Rhodes grass hay.					
Sheep 2—Eaten	+28.21	2.16	.38	2.75	6.28
Digested	3.29	—.16	—.03	.33	5.50
In urine	.16	.06	.15	.02	5.20
Loss or gain	3.13	—.22	—.18	.31	0.30
Sheep 3—Eaten	+40.04	3.07	.54	3.91	8.91
Digested	5.31	—.49	.43	—.03	7.03
In urine	.32	.27	.29	.04	7.36
Gain or loss	4.99	—.76	.14	—.07	—.33
Period 88—Alfalfa hay.					
Sheep 1—Eaten	6.82	8.12	1.96	4.19	12.27
Digested	3.31	.61	.47	—.11	7.54
In urine	.61	.05	.32	.03	8.32
Gain or loss	2.70	.56	.45	—.14	—.78
Sheep 2—Eaten	6.84	8.16	1.97	4.20	12.30
Digested	3.49	.76	.33	.87	9.86
In urine	.47	.09	.32	.04	10.24
Gain or loss	3.02	.67	.01	.83	—.38
Period 89—Alfalfa hay and burned cold pressed cottonseed.					
Sheep 1—Eaten	4.97	7.22	2.67	5.40	13.62
Digested	2.14	—.13	1.20	4.17	9.34
In urine	.77	.04	.32	2.07	6.88
Loss or gain	1.37	—.17	.88	2.10	2.46
Sheep 2—Eaten	4.97	7.72	2.67	5.40	13.62
Digested	—3.33	—2.49	.07	.87	9.04
In urine	.56	.09	.47	.07	8.00
Loss or gain	—3.89	—2.58	—.40	.80	1.04
Period 90—Peanut hulls and alfalfa hay.					
Sheep 1—Eaten	4.47	5.32	1.82	2.57	9.01
Digested	1.44	—.04	.70	—.22	6.90
In urine	.95	.05	.40	.16	6.24
Loss or gain	.49	—.09	.30	—.38	.66
Sheep 2—Eaten	4.53	5.37	1.86	2.58	9.15
Digested	1.09	—.54	.36	—.71	6.64
In urine	.92	.11	.37	.05	7.76
Loss or gain	.17	—.65	—.01	—.76	—1.02
Period 91—Rice hulls and alfalfa hay.					
Sheep 1—Eaten	26.31	3.84	.97	2.27	6.39
Digested	12.98	—.19	.31	.54	5.67
In urine	.69	.05	.16	.28	5.52
Loss or gain	12.29	—.24	.15	.26	.14
Sheep 2—Eaten	58.05	4.37	1.31	2.63	7.26
Digested	.62	—.84	.41	.94	4.59
In urine	.40	.06	.08	.06	5.04
Loss or gain	.22	—.90	.33	.85	—.45
Period 92.—Alfalfa hay.					
Sheep 1—Eaten	6.84	8.16	1.97	4.20	12.30
Digested	2.03	—.60	.50	.63	9.97
In urine	.75	.04	.28	.10	9.28
Loss or gain	1.28	—.64	.22	.53	.69
Sheep 2—Eaten	6.84	8.16	1.97	4.20	12.30
Digested	3.67	.84	.47	.84	10.81
In urine	.76	.06	.12	.05	9.92
Loss or gain	2.91	.78	.35	.79	.89

Table 13.—Grams excreted per day in urine.

Lab. No.		Silica.	Lime.	Magnesia.	Phosphoric acid.	Potash.
11225	Sheep 1—D. E. 76	0.192	0.045	.539	.013	6.42
11226	Sheep 2—D. E. 76	.120	.193	.498	.008	6.94
11297	Sheep 1—D. E. 78	.100	.146	.237	.027	3.10
11298	Sheep 2—D. E. 78	.078	.273	.452	.030	6.26
11339	Sheep 2—D. E. 79	.124	.090	.284	.023	9.78
11340	Sheep 3—D. E. 79	.284	.080	.172	.032	10.16
11500	Sheep 2—D. E. 81	.186	.033	.097	.036	8.68
11501	Sheep 3—D. E. 81	.264	.076	.762	.028	10.24
11526	Sheep 1—D. E. 82	.160	.058	.149	.022	5.20
11527	Sheep 2—D. E 82	.320	.268	.288	.036	7.36
12956	Sheep 2—D. E. 88	.610	.050	.322	.034	8.32
12957	Sheep 3—D. E. 88	.468	.090	.324	.040	10.24
12969	Sheep 2—D. E. 89	.768	.044	.316	2.072	6.88
12970	Sheep 3—D. E. 89	.556	.088	.468	.072	8.00
12980	Sheep 2—D. E. 90	.950	.049	.402	0.158	6.24
12981	Sheep 3—D. E. 90	.920	.110	.368	.048	7.76
13198	Sheep 2—D. E. 91	.688	.052	.160	.276	5.52
13199	Sheep 3—D. E. 91	.400	.053	.080	.064	5.04
13213	Sheep 2—D. E. 92	.748	.040	.284	.096	9.28
13214	Sheep 3—D. E. 92	.760	.064	.120	.048	9.92
	Average (20) except phosphoric acid of 12969	0.435	.095	.316	.055	7.57

SUMMARY AND CONCLUSIONS

1. Mineral constituents were estimated in one hundred thirteen tests on fifty rations, of which twenty tests on ten rations were balance experiments.

2. Potash has an average digestibility of 83 per cent.; magnesia 32.3 per cent., with no negative tests. With lime and phosphoric acid the digestibility in some cases is negative. The average for phosphoric acid is 22.5 per cent. and for lime 32.3.

3. The average digestibility of sulphur trioxide is 47.9 per cent. and for protein in the same tests 48.4. The sulphur may be in combination in the protein.

4. The average digestibility of silica (insoluble ash) is 22.2 per cent. and there are many negative tests.

5. The experiments are grouped according to quantities fed and averaged. The average quantities of lime and phosphoric acid digested increased as the quantities fed increased.

6. When the quantities fed and excreted in one group are subtracted from the succeeding group, the additional quantities of lime and phosphoric acid are found to have a fairly constant percentage digestibility. The digestibility of the additional lime averages about 25 per cent., and of the additional phosphoric acid, 50 per cent.

7. There are average losses of lime and phosphoric acid in the tests in the first group, in which the lowest quantities were fed, and average gains in all the other groups.

8. These facts point to a fairly constant digestibility of lime and phosphoric acid by the animal and a fairly constant excretion of lime and phosphoric acid by the animal in the solid excrement. The average excretion of lime is .60 gram, and of phosphoric acid .80 gram.

9. When one to two grams are fed, there are both losses and gains of phosphoric acid, and an increased consumption of lime was accompanied by an increased retention of phosphoric acid. A digestion of 1 gram of lime was accompanied by an increased retention of .74 gram phosphoric acid.

10. There were average gains of 1 gram silica (insoluble ash), .18 gram magnesia and .19 gram potash per day and head in the balance experiments. The silica in the urine averaged .44 gram.

11. The amount of phosphoric acid required in the feeds for a balance would average 1.70 grams per day and head for sheep weighing about 100 pounds. The amount of lime required in the feed for a balance would average 2.8 grams per day. The amount of magnesia would average 1 gram per day.